



## ***Standardization Process for Space Radiation Models Used for Space System Design***

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*Space Weather Week  
April 5-8, 2005*

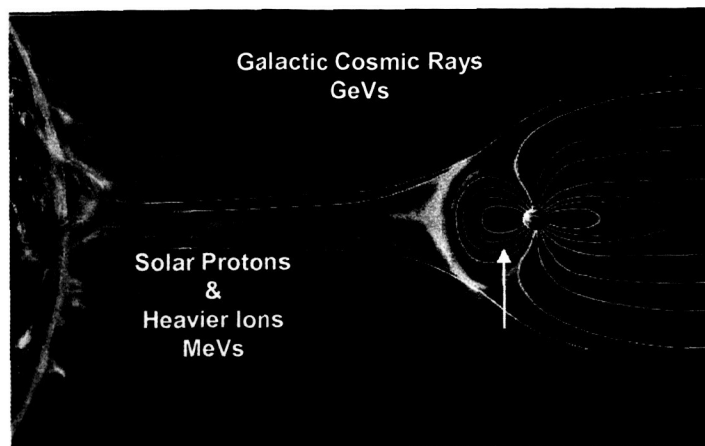


### **Introduction**

- **The space system design community has three concerns related to models of the radiation belts and plasma:**
  - AP-8 and AE-8 models are not adequate for modern applications;
  - Data that have become available since the creation of AP-8 and AE-8 are not being fully exploited for modeling purposes;
  - When new models are produced, there is no authorizing organization identified to evaluate the models or their datasets for accuracy and robustness.



## The Radiation Environment



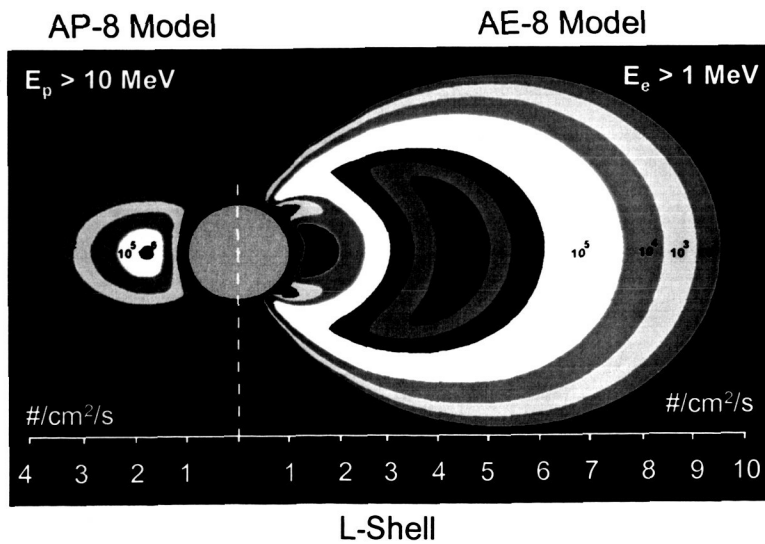
*Nikkei Science, Inc. of Japan, by K. Endo*

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## Trapped Proton & Electron Intensities



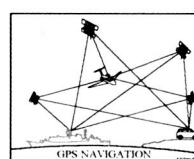
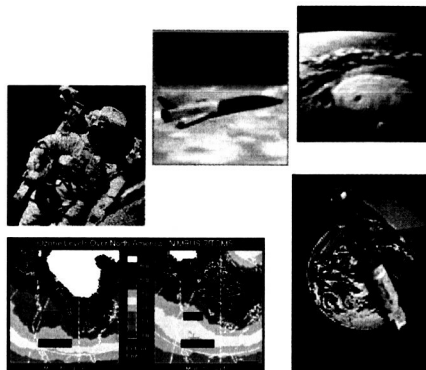
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## Missions in Space Radiation Environments

- Scientific Research
  - Space science
  - Earth science
  - Human exploration of space
  - Aeronautics and space transportation
- Navigation
- Telecommunications
- Defense
- Space Environment Monitoring
- Terrestrial Weather Monitoring

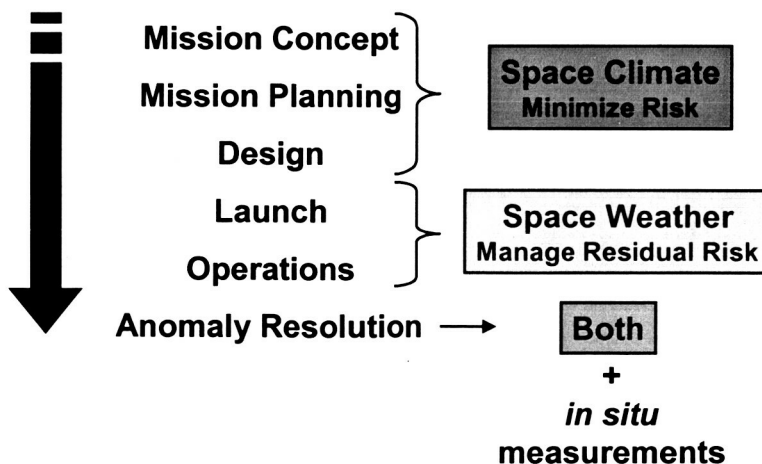


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## Space Environment Model Use in Mission Life Cycle



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## The Call for New Space "Climate" Models

- Identified by US Space Architect as a gap in the US Space Weather Program
- Identified by the US Space Technology Alliance's Space Environments and Effects Working Group as the #1 priority in space environments issues
- Identified in ESA R&D Roadmaps
- Why?
  - Required by engineers to build better spacecraft in pre-operation phases;
  - Used to support operational planning and on-orbit anomaly investigations;
  - Need for quantitative dynamic model of electron belt flux is the #1 environment concern for astronauts on ISS (*Golightly, LWS User Requirements Workshop, 2000*);
  - Need improved models for safe passage of astronauts and their vehicles through the radiation belts.

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## Working Group Meeting on New Standard Radiation Belt and Space Plasma Models

- Working Group meeting was held on 5-8 October 2004
- Included representatives from science, modeling, and user communities
- Goals
  - Report and document recent progress on radiation belt model and plasma model development
    - Metrics for past and current programs
  - Complete a roadmap for the development of new standard radiation belt and space plasma models for spacecraft engineering
    - Input to agencies for future investments
    - Interagency cooperation
- Organizing Committee
  - Janet Barth/NASA – Chair
  - Don Brautigam/AFRL
  - Bern Blake/Aerospace
  - Eamonn Daly/ESA



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## Working Group Panels

- **Four Panels met to develop roadmaps**
  - **Plasma environments in the magnetosphere**
    - Chair: Michele Tompsen/LANL
  - **Protons trapped in the magnetosphere**
    - Chair: Daniel Heyndriyx/BIRA
  - **Electrons trapped in the magnetosphere**
    - Chair: Bern Blake/Aerospace
  - **Flight dataset verification and model standardization processes**
    - Chair: Eamonn Daly/ESA
- **Model standardization activities are the result of the need for industry to have authorized models for space system design.**



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## Panel 4: Examination of Existing Capability

- **COSPAR Panel on Standard Radiation Belts (PSRB)**
  - Chair: Bourdarie, S. (France), 2004 - 2008
  - vice-Chairs:
    - Daly, E. J. (ESA/ESTEC), 2002 - 2006
    - Fung, S. F. (USA), 2002 - 2006
    - Panasyuk, M. I. (Russia), 2002 - 2006
  - **Terms of Reference:** The Panel was established to develop a standard model of the Earth's trapped radiation belts. The model should be based on experimental data using all available space data sources, while theoretical considerations will serve to guarantee optimal model construction and use, and internal consistency. The functionality of the model should be defined in terms of the needs of the user community. Guidelines should be defined for developing standardised radiation monitors. Where discrepancies exist between different data sources, the PSRB should promote critical discussion to establish the quality of the data sets. The model should be updated as new data become available and as old data bases are fully evaluated and exploited. A liaison should be established and maintained with the international scientific and space engineering communities, such as the IACG and ISO TC20/SC14/WG14, in order to ensure the availability and usability of data and models for radiation belt modelling and to encourage the sharing of modelling expertise.
- **ISO TC20/SC14/WG4 Space Environment (Natural & Artificial)**
  - WG4 Convenor: Prof. M. I. Panasyuk

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## Datasets and Modeling Standardization Roadmap (1/2)

- PSRB owns the process of dataset acceptance and modeling acceptance; supports ISO standardization;
- Update panel membership;
- Define acceptance criteria for datasets:
  - It is a PSRB task, but shall include (type, error bars, pre-flight calibration history, simulation, documentation, in-flight calibr. (e.g. conjunctions), coordinate system);
  - Datasets shall be made available to a sub-panel (peer review); report back to PSRB;
  - PI should be involved in the process and compare data.
- Issue calls for modeling datasets to feed the above
- Initiate in PSRB modeling “tasks” (decide today) and issue modeling calls (parallel);
- Define modeling acceptance criteria (handling propagation of errors, responding to user requirements, validation process, development timescale,...);

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## Datasets and Modeling Standardization Roadmap (2/2)

- Resulting draft model shall be put in public domain for evaluation (peers, industry);
- User community shall be part of the process;
- Test the ISO process: prepare a low-altitude proton model along these lines now, and generate an ISO *New Work Item* simultaneously;
- POLE electron model can also be done now in this process; other electron models later;
- Prepare a “process standard” via PSRB as an ISO activity
  - datasets and model characteristics;
- PSRB to meet before next COSPAR (China, 2006); ISO WG4 mtg. TBD + Toulouse 2005;
- Access methods, formats and support. PSRB discussion but not seen as a problem;
- The resources required are large, est. POLE ~1my; LAPM ~2my; others...
- The calls: Joint NASA+ESA+XYZ.

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## Two Models Recommended for Standardization

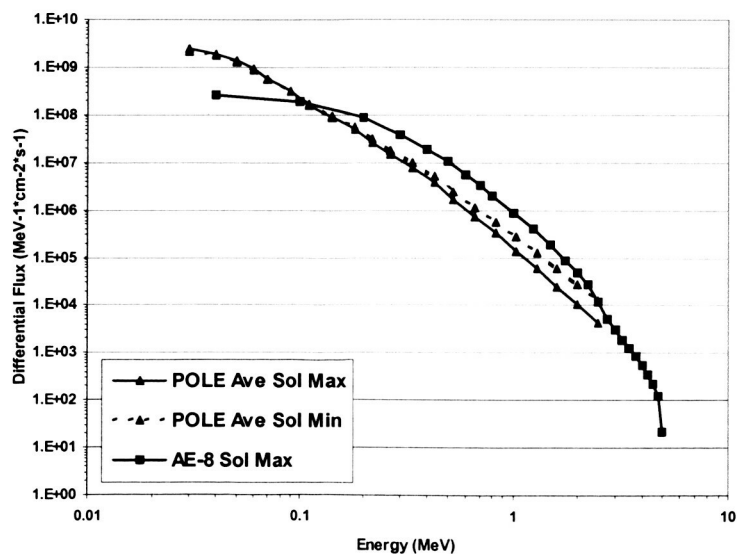
- Initiated as tasks in PSRB
- POLE (Particle ONERA-LANL Environment) Electron Model for geostationary orbits
  - Data sets: CPA and SOPA
- Low Altitude Proton (LAP) Model based on TPM-1/SAIC and PSB97/ESA
  - Data sets: TIROS, CRRES, SAMPEX

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## Comparison of POLE, AE-8

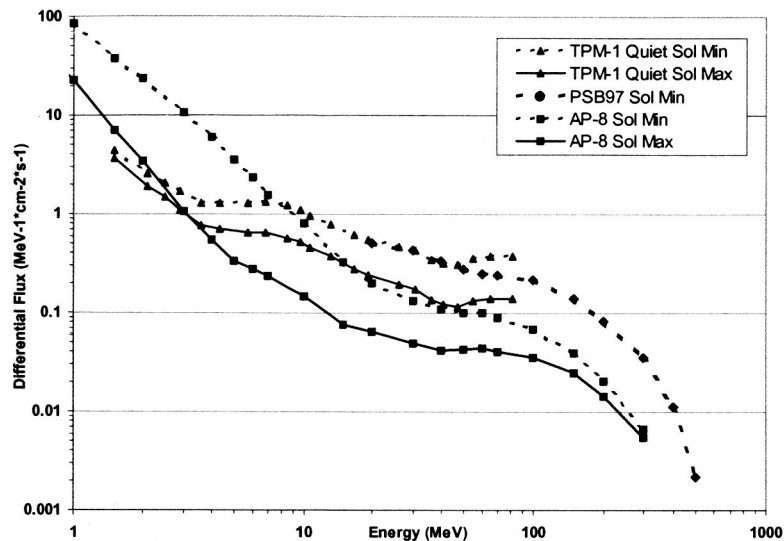


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## Comparison of TPM-1, PSB97, AP-8



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## Dataset Management Issues

- Need to break through the funding "Catch-22"
  - Radiation belt and plasma modeling not considered a science activity, But ...
  - Experimental space scientists must be a significant part of the modeling effort
- Acceptance process must be part of standardization activity.
- Need ancillary/meta data (calibration, simulation, performance,...)
- Need data access tools for users/modellers/validators/reviewers
- Format?
  - Raw + software vs. processed
  - Use of existing ventures (CSDS, CAA, CCMC, SEDAT,...)?
- Need documentation of process of model generation from data
- Distribution
  - Distributed vs. data center
  - Access and restriction

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## Summary

- Lack of Space "Climate" models is seen as a gap in Space Weather capability.
- Industry has a clear need for a model standardization process.
- Good tools and processes for comparing other models/implementations (i.e. benchmarking) needed.
- Modular, "bite-sized" approach encouraged for new model development.
- Strong version control on datasets, metadata, and models is required.
- **Manpower!**
  - Modeling activities for Space "Climate" models are not embraced by either the science or engineering communities.
- Products should be defined pre-flight.
- Need more meetings of the PSRB panel.

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